RESEARCH BULLETIN 1148 DECEMBER 1982

Recommended Genetic Selections of Some Forest Trees for Ohio

HOWARD B. KRIEBEL

The Ohio State University
Ohio Agricultural Research and Development Center
Wooster, Ohio

CONTENTS

* * *

ON THE COVER: In this Ohio seed source experiment, the white pine in the center is a superior selection from an eastern Tennessee seed source. At age 15, trees from seed of some Tennessee stands have a stem volume averaging one and a half times that of trees of the best native Ohio seed source.

AGDEX 300/41 12-82-2 5M

Recommended Genetic Selections of Some Forest Trees for Ohio

HOWARD B. KRIEBEL[1]

INTRODUCTION

Research on the genetic improvement of forest trees for planting in Ohio began in 1953. Subsequent results of selection and breeding experiments with a number of important species clearly demonstrate that significant gains in forest productivity can be obtained by use of the best available genetic material. Pressure to achieve these gains increases with rising demand for forest products and the mounting pressure of competitive land uses on Ohio woodlands. Ohio has a substantial land area which will continue to be best suited to forest management, although much of this area is currently low in forest productivity. One important step to increase productivity is the establishment of plantations of genetically faster-growing, pest-resistant types of tree species.

Recommendations in this publication are based on a long test period, usually 15 to 25 years. In three highly variable, widely distributed native species, namely eastern white pine, sugar maple, and red oak, recommendations are based on the sampling of trees of 30 to 50 geographic origins and of 5 to 10 seed trees within each origin. The eastern white pine recommendations are also based on: 1) data from controlled breeding experiments and open-pollinated progeny tests of native Ohio material, and 2) the results of 30 other range-wide and southern Appalachian seed source experiments in the eastern United States and Canada. The sugar maple recommendations are based on geographic variation patterns which are very systematic in relation to environmental and evolutionary factors, and hence highly reliable. Red oak recommendations are very specific because of the high degree of local genetic variation and near absence of geographic trends. The red oak seed source list will be supplemented in the future by recommendations derived from more recent studies.

Two exotic species, Balkan pine and Japanese larch, have very restricted natural distributions. Because of this, only a small number of seed collections of each species have been tested. However, trees of these seedlots probably demonstrate most of the variability present in each species. Since both species are adapted to Ohio's climatic conditions, the recommendations are made solely on the basis of vigor.

---

[1]Professor of Forestry.

Recommendations for other species and hybrids are based on samples from only a part of the natural distribution. Some of these recommendations may be revised as additional information is obtained with increasing age or from other experiments. Such recommendations are listed as tentative or as recommendations for additional testing. Recommendations are made only when, in the author's judgment, anticipated benefits from planting outweigh the risks.

Tree improvement research is a very time-consuming and costly procedure. Thus genetic variation in some important forest tree species has not been studied. However, current research within and outside Ohio will provide seed source recommendations in another one to two decades on several additional native and exotic species.

The reader should note that recommended genetic selections are listed in order of preference regardless of availability of seed or planting stock. Very few of the selections listed are currently available to the public from any nursery. The Ohio Agricultural Research and Development Center only has selections for its own research and cannot provide seed, seedlings, or cuttings, nor can it act as a clearing house for requests.

If sufficient demand for recommended selections of a species develops as a result of this publication, seed or nursery stock will probably be provided in time by public or private organizations. Inquiries about the availability of a particular species or seed source should be directed to the Division of Forestry, Ohio Department of Natural Resources, or to commercial nurserymen. Information and technical advice on the suitability of the species listed herein for different sites, and on methods of establishing and maintaining forest plantations, are available without charge from the Cooperative Extension Service, Division of Forestry, The Ohio State University, and from service foresters of the Ohio Division of Forestry.

With the exception of the planting stock recommendation for the establishment of high-yield maple syrup orchards, and as otherwise noted, all recommendations are for genotypes suitable for timber production, either sawtimber or pulpwood. Recommendations for production of Christmas trees, ornamentals, and shade trees are provided in other OARDC or Cooperative Extension Service publications.

A list of common and scientific names of trees and of a few relevant pest organisms is provided in the Appendix.

CONIFERS

Eastern white pine *(Pinus strobus* L.*)*

In OARDC experiments, white pine from all recommended sources has good form and a high level of air pollution tolerance. Because of natural screening at the test site, trees from source No. 5 have a higher probability than others of being resistant to white pine root decline. This disease can kill some trees in white pine plantations, especially those established on fine-textured, poorly drained soils. Recommended seed sources, and examples showing the unfavorable growth rate of non-recommended sources, are listed in Table 1.

Relative Vigor of Some White Pine Species and Hybrids

About 20 species of white pines and numerous hybrids have been tested in breeding experiments. Some are superior in vigor to eastern white pine. Table 2 ranks some of these species and hybrids on the basis of a very limited number of clones in three field tests in Wayne County, Ohio. The ranking is sufficiently similar to that reported for trees of seedling stock in several other locations in the USA and Canada to give a good indication of relative growth rates. None of the hybrids will be commercially available in the foreseeable future, except for the hybrid white x blue pine *(P. strobus* x *griffithii)*, as indicated later in this publication.

Of the species and hybrids listed, only those specifically discussed have known genotypes suitable for Ohio planting. The hybrids which exceed eastern white pine in vigor merit further research. There is no near-term prospect of this, however, because of the difficulty and cost of controlled hybridization and the low yields of viable seed.

Blue pine *(Pinus griffithii* McClel.*)*

Blue or Himalayan pine frequently outgrows eastern white pine, especially in volume growth, but trees of many seed sources are not winter-hardy, and form is sometimes undesirable because of sweep or heavy limbs. OARDC test material includes trees of 100 seed sources from Afghanistan, Pakistan, Kashmir, India, and Nepal, and from several winter-hardy trees of unknown original source growing in Canada.

The ranking in Table 3 is tentative because trees of most sources were only 8 years old at the time of last measurement, although they had been through two severe winters in Ohio. Further small-scale testing in varied environments should precede any extensive planting with this material. Currently, the best progenies are from Canadian crosses, followed by trees from some stands on the west side of the valley of Indian Kashmir.

Eastern white x blue pine hybrid *(P. strobus* x *griffithii)*

So far, up to age 22, this hybrid is usually superior to either eastern white pine or blue pine in Ohio. Volume growth generally exceeds that of eastern white pine (Table 4), and the hybrid appears to have a good combination of the winter-hardiness of eastern white pine and the vigor of blue pine. Because viable seed yield is nearly as high as that of eastern white pine crossed with its own species, a hybrid seed orchard consisting of a mixture of white and blue pines has been established in southeastern Ohio. If satisfactory natural pollination takes place and no catastrophe occurs, trees from hybrid seed will be available about 1990 from the Ohio Department of Natural Resources. Eastern white pine parents are average Memorial State Forest trees. Blue pine parents currently include 29 seed origins in India and Pakistan.

Southwestern white pine *(Pinus strobiformis* Engelm.*)*

This species grows slightly slower than eastern white pine in Ohio but is well-adapted to this climate and provides genetic diversity for forest planting of soft pines. This could be desirable insurance against outbreak of a new or presently unimportant insect or disease which might seriously affect eastern white pine.

Trees of only three seed sources have been under long-term test (Table 5). Additional research may indicate that trees from other origins outperform those listed.

Balkan pine *(Pinus peuce* Griseb.*)*

The Balkan pine, or Macedonian white pine, is native to high elevations on a few mountain ranges in southern Yugoslavia, Albania, and western Bulgaria. Its moderate growth rate, compared with that of eastern white pine, limits its use for timber production to situations in which fast growth is exceeded in importance by a higher level of resistance to white pine blister rust and the white pine weevil than that found in eastern white pine. Blister rust is not a problem in Ohio, but the weevil could become a serious pest with increasing acreage in pure stands of white pine. The Balkan pine is highly tolerant of air pollution in OARDC experiments. Its highest value is for ornamental use and possibly as a premium Christmas tree species. Recommended sources are listed in Table 6.

European black pine *(Pinus nigra* Arn.*)*

European black pine includes several very similar subspecies or varieties which are not clearly separated from each other. The best known of these in Ohio are the Austrian pine *(P. nigra* var. *austriaca* (Hoess)

Asch. & Graebn.), of the eastern Alps and southeastern Europe, and the Corsican pine (*P. n.* var. *poiretiana* (Ant.) Schneider, syn. *P. n.* var. *laricio* (Poiret) Marie).

The critical selection factor for European black pine in Ohio is resistance to needle diseases. At age 23, all 23 of the seed sources of this species in Experiment AC-8 in Wayne County have been affected by *Diplodia* tip blight after three successive rainy summers. An 18-year-old plantation of trees from Panos, Visegrad, Yugoslavia, (Experiment AC-17) is so far virtually unaffected, but a buildup of infection over 2 or 3 years could result from its proximity to the 23-source plantation. Trees from Yugoslavia have, however, been resistant to *Dothistroma* needle disease in Nebraska.

If trees of the single unaffected Yugoslavia source remain disease-free for several years, they will provide a source of seed for additional testing. Seed of another central Yugoslavia origin is also available and will be used for further testing for disease resistance.

Thus, results to date provide no recommended seed sources for general planting of European black pine in Ohio. Testing of additional Yugoslavian seed sources in replicated locations is recommended. The minimum testing period should be 25 years.

European black x Japanese red pine hybrid (*P. nigra* Arn. x *P. densiflora* Sieb. & Zucc.)

This hybrid is more vigorous than *Pinus nigra* and provides needed additional genetic diversity for hard pine planting in Ohio. Stem form is variable but not as straight as that of European black pine. Acceptable form can be obtained from an initial moderately close spacing followed by selective thinning and pruning of crop trees. Table 7 lists the only current source of available seed. A small "hybrid seed orchard" of intermixed European black pine and Japanese red pine should be established in Ohio.

Shortleaf pine (*Pinus echinata* Mill.)

Shortleaf pine, although native to southeastern Ohio, is not generally winter-hardy over most of the state. Because of the need for plantable hard pines in Ohio and because of shortleaf pine's high quality as a pulpwood species, population samples from six northern seed sources ranging from New Jersey to Missouri were tested in north-central Ohio, and in southeastern Ohio on strip-mine spoil banks. Only trees of Pennsylvania origin had adequate survival for a qualified recommendation (Table 8). The recommendation is qualified because there has been snow damage to some trees in the Wayne County test.

Japanese larch (*Larix leptolepis* (Sieb. & Zucc.) Gord.)

Trees of all seven seed sources of Japanese larch tested in northern Ohio (Wayne County) have been winter-hardy. There have been no significant differences in form or pest resistance. Height increment of the recommended sources is 2/3 meter or 2.2 feet per year and compares favorably with that of other conifers. The species is also an attractive ornamental.

The two seed sources with the highest volume growth rate are listed in Table 9.

HARDWOODS

Sugar maple (*Acer saccharum* Marsh.)

In northern Ohio, sugar maple from any seed source north of the coastal states and Georgia is winter-hardy and survives well. Except for seed source No. 1 in Table 10, trees of northern Ohio origin outgrow others. Any northern Ohio stand with well-formed trees is a good seed source for timber production in that part of the state.

Of the 21 geographic seed sources tested in southeastern Ohio, the southern Illinois source can be recommended for high survival capacity. Because of its slow growth, it is only useful as an ornamental.

Improved sugar bush planting stock is periodically available from the Ohio Department of Natural Resources. The trees are grown from seed collected in a special plantation of high-performance clones at the OARDC.

Red oak (*Quercus rubra* L.)

The inherent vigor of red oak has very little relation to geographic origin at middle latitudes. Stand selection is the appropriate procedure for seed collection. The listed recommendations are based on the average vigor of 5 to 10 families of each of the seed sources (*i.e.*, stands) listed. They are the best of 32 seed sources. Additional recommendations will be made later, based on younger Ohio stand selection experiments.

Black walnut (*Juglans nigra* L.)

Only general recommendations can be made for the selection of black walnut seed sources for timber production plantations. Seed for black walnut plantations in Ohio may be collected in West Virginia, Ohio, Kentucky, Tennessee, and Indiana. Trees from seed collected in this region have had the highest growth rate in Wayne County, Ohio, up to age 16 in a 25-origin experiment. Similar experiments in other mid-

western states have a comparable growth pattern. Thus, the recommended seed collection zone can be considered applicable throughout Ohio.

Collection of black walnut seed from trees native to regions south and west of the above region should be avoided. Southern trees are not winter-hardy in Ohio and western trees grow more slowly.

Within the recommended seed collection zone, seed tree selection should be based on the visible characteristics of trees in the best available stands of merchantable or near-merchantable size. Relative vigor and straightness of stem are the principal field selection criteria for timber production.

APPENDIX

Index of Common and Scientific Names

Eastern white pine	*Pinus strobus* L.
Blue (Himalayan white) pine	*Pinus griffithii* McClel.
Southwestern white pine	*Pinus strobiformis* Englem.
Balkan pine	*Pinus peuce* Griseb.
Limber pine	*Pinus flexilis* James
Western white pine	*Pinus monticola* ex D. Don
Japanese white pine	*Pinus parviflora* Sieb. & Zucc.
Korean pine	*Pinus koraiensis* Sieb. & Zucc.
Swiss stone pine	*Pinus cembra* L.
European black pine	*Pinus nigra* Arn.
Japanese red pine	*Pinus densiflora* Sieb. & Zucc.
Shortleaf pine	*Pinus echinata* Mill.
Japanese larch	*Larix leptolepis* (Sieb. & Zucc.) Gord.
Sugar maple	*Acer saccharum* Marsh.
Red oak	*Quercus rubra* L.
Black walnut	*Juglans nigra* L.
White pine blister rust	*Cronartium ribicola* J. C. Fischer ex Rabenh.
White pine root decline	*Verticicladiella procera* Kendrick
Dothistroma needle blight	*Dothistroma pini* Hubl.
Diplodia tip blight	*Diplodia pinea* (Desm.) Kickx.
Lophodermium needle cast	*Lophodermium pinastri* (Schad. ex Hook.) Chev.
White pine weevil	*Pissodes strobi* Peck

TABLE 1.—Recommended Sources of Eastern White Pine Seed.

Recommended Seed Sources in Order of Preference*	Age of Progeny When Measured	Mean Stem Volume, Percent of Source No. 10
1. MSFG 3532 to 3541, near city of Oak Ridge, Anderson County, TN, lat. 36° 00' N, long. 84° 10' W, elev. 275 m (900')	15	155
2. MSFG 3493 to 3502, 13 km (8 miles) west of Copperhill, Polk County, TN, lat. 35° 00' N, long. 84° 25' W, elev. 457 m (1500')	15	148
3. MSFG 3542 to 3544, near Cooper Creek, Fannin County, GA, Toccoa Ranger District, Chattahoochee National Forest, lat. 34° 44' N, long. 84° 09' W, elev. 610 m (2000'). U.S.F.S., Gainesville, GA	15	143
4. MSFG 3409 to 3418, 19 km (12 miles) south of Asheville, Buncombe County, NC, slightly east of highway US 25A, 400 hectare (1000 acre) tract owned by Christ School, lat. 35° 30' N, long. 82° 30' W, elev. 610 m (2000')	15	141
5. AC-14 and AC-15, OARDC seed orchard, Apple Creek Developmental Center, Wayne County, OH, 2 km (1.2 miles) north of Apple Creek, Oh, lat. 40° 46' N, long. 81° 51' W, elev. 378 m (1240'); selected crosses from Source No. 10	17, 18	140
6. MSFG 3513 to 3521, 24 km (15 miles) southeast of Blue Ridge, Fannin County, GA, Blue Ridge Ranger District, Chattahoochee National Forest, lat. 34° 35' N, long. 84° 10' W, elev. 450 m (1500')	15	133
7. MSFG 873, OARDC 571, 606, Pocono Crest Hotel, Tobyhanna Township, Monroe County, PA, between hotel and PA Route 940, lat. 41° 05' N, long. 75° 25' W, elev. 550 m (1800')	20	106
8. Gifford White Pine Seed Orchard, 1 km (0.6 miles) N of Sharpsburg, Athens County, OH, Gifford State Forest, lat. 39° 27' N, long. 81° 54' W, elev. 208 m (680'); grafted selections from native and planted Ohio stands	15, 19	100-110
9. Memorial State Forest White Pine Seed Orchard, McCurdy Road, NE ¼ NW ¼ section 28, T19N, R16W, lat. 32° 35' N, long. 82° 17' W, elev. 366 m (1200'); a replicate of Source No. 8	10	100-110
10. Natural stands, Mohican and Memorial State Forests and vicinity, Ashland County, OH, lat. 40° 36' N, long. 82° 18' W, elev. 396 m (1300')	16, 17, 18, 20, 24	100

*Two Morgan County, TN, seed sources ranked between the Anderson and Polk County sources in tests in Tennessee (Thor, 1981, personal communication). These sources are not in the OARDC experiments, but the ranking of white pine seed sources in Tennessee closely parallels that in Ohio.

TABLE 1 (Continued).—Recommended Sources of Eastern White Pine Seed.

	Age of Progeny When Measured	Mean Stem Volume, Percent of Source No. 10
Examples of non-recommended seed sources		
NEG-6, OARDC 588, Anthony Creek, Alvon, Greenbrier County, WV	20	85
OARDC 287, St. Clair Township, Columbiana County, OH	24	80
NEG-19, OARDC 579 and 612, 12 km (7.5 miles) W of Cass Lake, Cass County, MN	20	72
OARDC 292, 10 km (6.2 miles) E of Mountain City, Johnson County, TN	24	67
OARDC 282, Fallsburg Township, Licking County, OH (5 tree population)	24	28

TABLE 2.—Clonal Comparisons of Height Growth Rate of Some White Pine Species and Hybrids (ages 16-23).*

Species or Hybrid†	No. of Clones	Mean Annual Ht. Growth, meters	(feet)‡	Standard Deviation, meters	Percent of Mean: All Species and Hybrid Clones	Percent of Mean: E. White Pine Clones	Rank
Blue (Himalayan white) pine	4	0.45	(1.5)	0.08	145	135	1
Southwestern x blue pine	2	0.40	(1.3)	0.05	126	118	2
Western white x blue pine	2	0.40	(1.3)	0.08	126	118	2
Western white pine	2	0.40	(1.3)	0.05	126	118	2
Western white x Balkan pine	2	0.38	(1.2)	0.04	119	112	3
Japanese white pine var. **pentaphylla**	1	0.37	(1.2)		116	109	4
Eastern white pine	37	0.34	(1.1)	0.17	107	100	5
Western x eastern white pine**	2	0.33	(1.1)	0.17	104	97	6
Western x Mexican white pine	2	0.32	(1.0)	0.02	101	94	7
Balkan pine	10	0.29	(1.0)	0.06	91	85	8
Western x Japanese white pine	1	0.29	(1.0)		91	85	8
Limber pine	3	0.27	(0.9)	0.04	85	79	9
Korean pine	2	0.25	(0.8)	0.01	79	74	10
Japanese white pine var. **himekomatsu**††	2	0.16	(0.5)	0.05	50	47	11
Swiss stone pine	1	0.11	(0.4)		35	32	12

*Scions are grafted on eastern white pine rootstocks. Species and hybrids suitable for planting or for additional testing are discussed in the text. The hybrid eastern white x blue pine, which was not grafted, is listed in a separate section.

†Common and scientific names are listed in the Appendix. Hybrid designations list the female parent first; **e.g.,** limber x blue pine progenies have limber pine as the female (seed) parent and blue pine as the male (pollen) parent.

‡Grafted trees normally grow more slowly than trees on their own roots.

Eastern white x western white pine, the reciprocal cross, is distinctly inferior in vigor to eastern white pine in OARDC progeny tests from controlled pollinations; **i.e., when grown from seedlings instead of grafted as were the hybrids listed. Pollen sources were limited to a few northern Idaho trees. In some other parts of the U. S., the hybrid is superior to eastern white pine.

††The varietal identity is probable but not certain.

TABLE 3.—Recommended Sources of Blue Pine for Additional Adaptability Testing in Ohio.

Tentative Seed Source Recommendations for Additional Test Plantations, in Order of Preference	Age of Progeny or Clone when Measured	Percent Survival	Mean Height, Percent of All Source Mean
1. IUFRO 6057, Maple WP 1297 (5-322) Arnold Arb. x Morris Arb. 4532, controlled cross of two trees growing at Ontario Forest Research Centre, Maple, Ont.	8	83	158
2. IUFRO 6056, Maple WP 1296 (5-315), Arnold Arb. x Morris Arb. 4532, controlled cross of two trees growing at Ontario Forest Research Centre, Maple, Ont.	8	83	152
3. IUFRO 6058, Maple WP 1298 (5-323), Arnold Arb. 22932-B x Morris Arb. 4532, controlled cross of two trees growing at Ontario Forest Research Centre, Maple, Ont.	8	94	142
4. IUFRO 6030, Tanmarg-1, Tanmarg, Kashmir, India, lat. 34° 04' N, long. 74° 26' E, elev. 1828 m (6,000')	8	100	126
5. OARDC 1594, Maple 5-323 (Arnold Arb. 22932-B), grafted OARDC trees from a Maple, Ont. tree grafted from an Arnold Arboretum tree	19	88	120*†
6. IUFRO 6059, Maple WP 1299 (5-327 Morton Arb. x Morris Arb. 4532), controlled cross of two trees growing at Ontario Forest Research Centre, Maple, Ont.	8	75	119
7. IUFRO 6021, Srinagar P-1, Srinagar, Kashmir, India, elev. 1737 m (5,700')	8	92	106
8. IUFRO 6029, Yusmarg-1, Yusmarg, Kashmir, India, lat. c. 33° 45' N, long. c. 74° 40' E, elev. 2255 m (7,400')	8	94	103
9. IUFRO 6036 to 6045, BR-32, Panjoul (Peshawar), Hazara, Pakistan, lat. 34° 39' N, long. 73° 18' E, elev. 2956 m (9,700')	8	76	97
10. OARDC 1240, Maple, Ont. 423, grafted OARDC trees from a Maple, Ont., tree grafted from a tree at Glendon Hall Estate, Toronto, Ont.	19	75	96*

NOTE: Trees from Nepal are not winter-hardy. Trees from Uttar Pradesh and Himachal Pradesh provinces of India, although above average in vigor, are not sufficiently winter-hardy to be recommended on the basis of OARDC experiments.

*This figure is the ratio of mean annual growth to overall mean annual growth of four winter-hardy blue pine clones.

†The average annual growth of grafted trees of Source No. 5 was 162% of that of comparable eastern white pine trees. Trees of other seed sources are too young for comparison to be made with growth of eastern white pine.

TABLE 4.—Stem Volume of Eastern White Pine x Blue Pine Hybrid Families Relative to That of Eastern White Pine, at Ages 17 to 22.*

Ranked Seed Sources of Parents of Listed Hybrid Progeny or Progenies, and Identification of Experiment†	Number of Progenies		Age	Relative Volume, Percent of E. White Pine Control
	Hybrid	E. White Pine Control		
1. Eastern white pine, average Memorial State Forest (Ohio) tree, x blue pine OARDC 629 (IFG Placerville EX-VI), origin unknown, from Lucknow, India, experiment AC-12	1	1	19	144
2. Eastern white pine, average Memorial and Mohican State Forest (Ohio) trees, x blue pine OARDC 1057 (n. Idaho FGC P.WA.-2), origin unknown, planted at Asakawa Arboretum, Govt. Forest Exp. Station, near Tokyo, Japan, lat. 35° 30' N, long. 140° E, experiment AC-14	3	11 best of 33	18	134
3. Eastern white pine, average Memorial State Forest (Ohio) trees, x blue pine OARDC 1213 (n. Idaho FGC P.WA -7), near Dalhousie, Chamba, Himachal Pradesh, India, lat. 32° 27' N, long. 76° 32' E, elev. 2743 m (9,000'), experiment AC-15	2	10 best of 31	17	122
4. Eastern white pine, OARDC 660 and 663, origin unknown, from Secrest Arboretum, x blue pine OARDC 505, origin unknown, last survivor in Secrest Arboretum (Plot G-27, established in 1918), Experiment AC-12	2	1	22	99

*Planting stock of this hybrid may be available about 1990 from the Ohio Department of Natural Resources, from a special plantation designed to produce seed.

†The experiment is near Apple Creek, Wayne County, OH, on silt loam soil.

TABLE 5.—Recommended Seed Sources of Southwestern White Pine.

Recommended Seed Sources in Order of Preference	Age of Progeny When Measured	Mean Annual Height Growth, meters (feet)*	Mean Stem Volume, Percent of Slowest-growing Source*
1. MSFG 905, OARDC 1230, Capitan, Lincoln National Forest, Lincoln County, NM, lat. 33° 33' N, long. 105° 34' W, elev. 2438 m (800')	19	0.31 (1.0)	136
2. MSFG 932, OARDC 1231, Osha Canyon, Taos and Rio Arriba Counties, NM, lat. 36° 20' N, long. 105° 40' W, elev. 2134 m (7,000')	19	0.30 (1.0)	134
3. MSFG 904, OARDC 1229, San Francisco Peaks (Flagstaff), Coconino National Forest, Coconino County, AZ, lat. 35° 20' N, long. 111° 40' W, elev. 2775 m (9,100')	19	0.27 (0.9)	100

*The test plantation is near Apple Creek, Wayne County, OH, on silt loam soil (Experiment AC-13).

TABLE 6.—Recommended Seed Sources of Balkan Pine.

Recommended Seed Sources in Order of Preference	Age of Progeny When Measured	Mean Height, meters (feet)*	Mean Stem Volume, Percent of Slow-growing Source*
1. 1671 to 1680, Rila Mountain, Bulgaria, NE slope, elev. 1700-1750 m (5500-5700')	12	0.61 (2.0)	117
2. 1670, Pelister Mountain, Macedonia, Yugoslavia, N aspect, elev. 1220 m (4000')	12	0.50 (1.6)	100

*The experiment is at the Pomerene Forest, Coshocton County, OH, on loam to silt-loam soil (Experiment Po-30). Slow growth during years 1 to 6 distorts absolute growth rate values.

TABLE 7.—Recommended Seed Source of the Hybrid European Black x Japanese Red Pine.

Recommended Seed Source	Age of Progeny When Measured	Mean Volume of Hybrids, Percent of Mean of Intermixed Black Pine*
MSFG 3955, OARDC 1879, European black pine plantation of unknown origin, age 41, with a nearby Japanese red pine plantation, in the eastern half of the Kellogg Forest (Michigan State University), Augusta, MI	15	139

*The European black pine trees are from the same seedlot as the hybrids. About half of the seedlings from the seedlot were hybrid. The rest were pure European black pine. The test is at the OARDC on a silt loam soil (Experiment L-21).

TABLE 8.—Recommended Seed Source of Shortleaf Pine for Additional Adaptability Testing in Ohio.

Recommended Seed Source*	Test Location	Soil Type	Age of Trees	Percent Survival	Mean Height, meters (feet)	Stem Volume as Percent of Six Source Test Mean
OARDC 297, Mont Alto, Guilford Township, Franklin County, PA, elev. 275 m (900')	Wayne County	silt loam	22	81	10.4 (34)	126
	Morgan County	high pH spoil†	22	68	6.9 (23)	94
	Perry County	low pH spoil†	22	36	7.3 (24)	86

*This is one of six northern seed sources of shortleaf pine, including: Burlington County, NJ; Franklin County, PA; Vinton County, OH; Laurel County, KY; Jackson County, IL; Douglas County, MO. Survival of trees of the five sources not listed varied from 6 to 39%.

†The strip-mine spoil banks are respectively pH 7.2-7.5, comparatively rich in essential nutrients but with poor physical properties, and pH 4.0 with sandy texture, good waterholding capacity, and low fertility.

TABLE 9.—Recommended Seed Sources of Japanese Larch.

Recommended Seed Sources in Order of Preference	Age of Progeny When Measured	Mean Height, meters (feet)*	Mean Stem Volume, Percent of All Source Mean*
1. OARDC 673 (MS-4, Schmalenbeck 9 [2793]), Fujimi, Nagano Prefecture, Nishidake National Forest, lat. 35° 36' N, long. 138° 19' E, elev. 1,450 m (4750') (volcanic ash)	23	15.1 (50)	132
2. OARDC 672 (MS-3, Schmalenbeck 4 [2788]), Kawakami, Nagano Prefecture, Azusayama National Forest, lat. 35° 36' N, long. 138° 41' E, elev. 1,500 m (4900') (sandy clay)	23	15.1 (50)	108

*The test location is near Apple Creek, Ohio, on silt loam soil (Experiment AC-7).

TABLE 10.—Recommended Seed Sources of Sugar Maple.

Recommended Seed Sources	Age of Progeny When Measured	Mean Height, meters (feet)*	Mean Height as Percent of Average Northern Ohio
1. OARDC 21 to 25, Funk's Grove, McLean County, IL, elev. 213 m (700'); this recommendation is for northern Ohio only	20	10.0 (33)	105
2. Any average northern Ohio stand with trees of good form; this recommendation is for northern Ohio only	20	9.6 (32)	100
3. OARDC 26 to 30, Jonesboro, IL Ranger Station, U. S. Forest Service, Twp. 12S R2W, Union County, IL, elev. 161 m (530'); for ornamental use on dry sites	20	8.8 (29)	92

*The experiment is at Wooster, OH, on silt loam soil (Experiment L-15). Trees of Source No. 3 were two-thirds as tall in Meigs County in southeastern Ohio as at Wooster.

TABLE 11.—Recommended Seed Sources of Red Oak.

Recommended Seed Sources in Order of Preference	Age of Progeny When Measured	Mean Height as Percent of All Source Mean*
1. OARDC 841 to 850, Irvine, Warren County, PA, lat. 41° 50' N, long. 79° 15' W, elev. 360 m (1180')	14	113
2. OARDC 981 to 990, East Waterboro, York County, ME, lat. 43° 30' N, long. 70° 45' W, elev. 91 m (300')	14	113
3. OARDC 761 to 768, Paoli, Orange County, IN, lat. 38° 30' N, long. 86° 30' W, elev. 235 m (770')	14	112
4. OARDC 901 to 910, Wasaga Beach, Simcoe County, Ontario, lat. 44° 30' N, long. 80° 00' W, elev. 180 m (590')	14	108

*Means are based on the overall performance of each listed seed source in northern Ohio, northern Indiana, and southern Indiana experimental plantations.